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13. ABSTRACT

This ~~final~~ report summarizes the activity of an 18-month exploratory attempt to develop a telemetry technique to monitor alerting responses in military dogs, and to transmit and record the resultant physiological data. The program also attempted to evaluate the feasibility of controlling behavior by telemetric means. The latter effort was abandoned when it became apparent that social rewards were more effective in shaping behavior than electronically generated cues such as audible sine wave frequency tones and mild electric shock. Two techniques for monitoring alerting responses at distances to one mile were investigated: heart rate changes and skin temperature changes. Heart rate changes were monitored using silver-silver chloride conductive gel electrodes mounted in a harness to detect electrocardiographic voltages at the surface of the skin, the information transmitted and processed for visible presentation using a field portable receiver-tachometer system. Skin temperature changes were investigated with thermistor bead sensors placed externally on the dorsal surface of the neck and anchored with either urethane or silicone foam. Technical feasibility of the experimental technique under field conditions was demonstrated.

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PROGRAM OBJECTIVES

This investigation was an exploratory attempt to develop a technique for monitoring alerting responses in military dogs and to transmit physiological responses to alerting stimuli by telemetry. The program also attempted to evaluate the feasibility of controlling behavior by telemetry.

DISCUSSION

With regard to control of behavior, we were basically unsuccessful. The plan was to condition several experimental dogs to respond to acoustic signals. The scheme involved the development of a cue which would notify the dog that a problem existed which he was required to solve. Two additional tones were provided to the animal which were intended to indicate that the dog was either approaching a solution to the problem or not approaching a solution. While much diligent effort was expended on four different dogs, we were forced to conclude the following:

1. Social rewards were far more powerful an influence in the control of dog behavior than any tone signals transmitted by a handler's transmitter and received on the dog's harness. Several comparative

attempts were made to evaluate standard techniques of praise and petting against food reward and paired audio signals. In every case the handling, petting and the physical action of the trainer was a more effective influence in shaping behavior.

2. The tones provided were basically sine wave frequencies in the audible range. Both dogs and trainer had difficulty in pitch discrimination. More complex tones were employed but these did not alleviate the basic difficulties with the method.

3. Light electric shocks were explored as a means of indicating negative guidance or avoidance stimuli. A short experience with this technique was unrewarding. Either the shock was not sufficiently irritating to the animal and was ignored, or the shock was traumatic enough to cause a permanent avoidance to all conditions associated with the shock. The total training environment was intended to be a rewarding rather than an unpleasant experience for the subject animals. Under these conditions social rewards became the most powerful stimulus for behavior control. It is likely that results could have been obtained under conditions of deprivation.

4. Selection of experimental animals for this purpose was basically a military responsibility. Two

of the four animals used were slow to learn and placid with regard to alerting stimuli.

TELEMETRY OF PHYSIOLOGICAL RESPONSES

Alerting responses can be found in heart rate changes, redistribution of peripheral blood flow, postural changes, pilar erection and breathing changes.* In an alert concerned dog these responses occur in various degrees to unusual or novel stimuli, to situations where the dog recognizes a threat, and in cases where the dog responds aggressively to another animal. We investigated two techniques for monitoring alerting responses during this program: first, heart rate shifts, and second, skin temperature changes.

EXPERIMENTAL PROCEDURES

1. Heart Rate Change Monitor for Alerting Responses:

The general objective for instrumentation design was as follows: To design a heart rate detector that could be applied in a harness externally to the body surface and be capable of reporting continuous record of heart rate over distances of one mile under field conditions. Conductive gel electrodes were mounted in a harness for the detection of electrocardiographic voltages at the surface of the skin. The circuit was designed to amplify the EKG,

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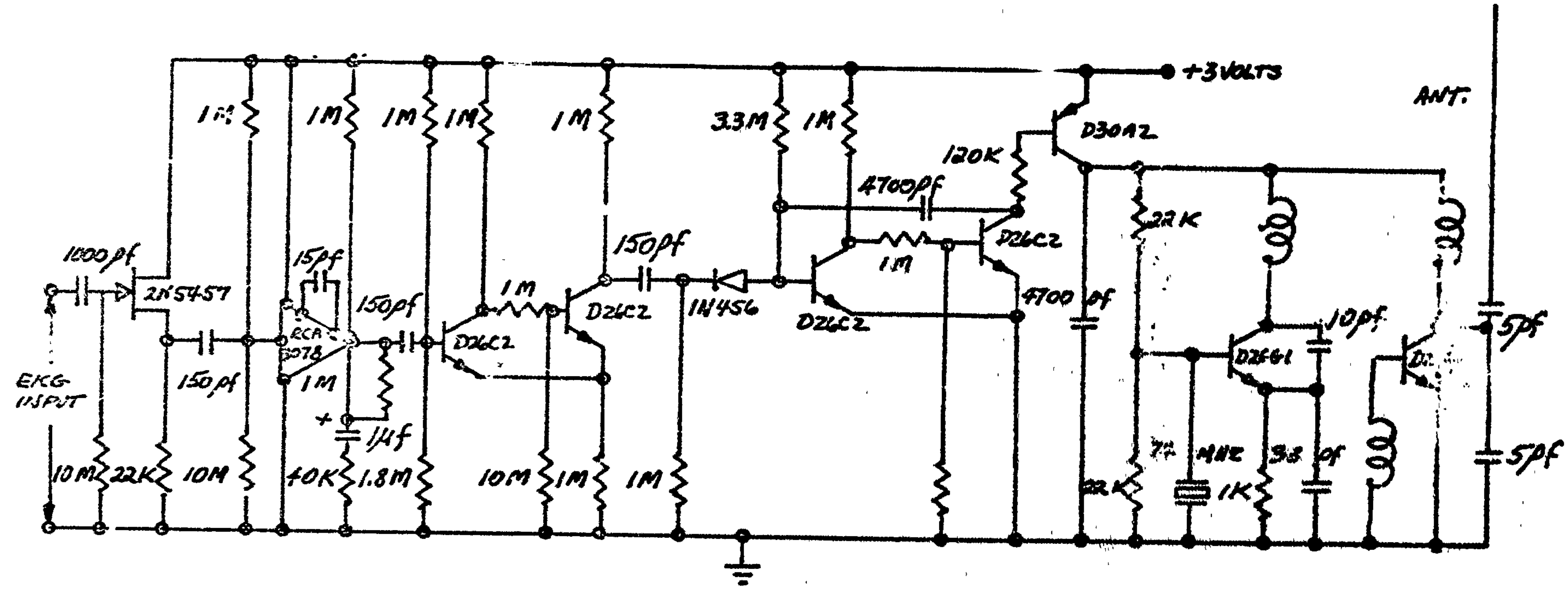
* Lynn, R., Attention, Arousal and the Orientation Reaction, Pergamon Press (1966)

filter out low frequencies and use the QRS complex of the electrocardiograph to trigger or gate an RF transmitter; the transmitter then provided a pulse per heart beat. RF pulses were received in a conventional receiver, reshaped and passed through a tachometer which provided a DC output proportional to rate. This heart rate presentation was available visibly and audibly and displayed either on a meter or chart recorder. The heart rate changes due to alerting stimuli were selected from heart rate changes associated with activity or metabolism by choice of an appropriate time constant in the filter section of the tachometer.

Electrodes selected were those available for use in human EKG studies during exercise. They consisted of silver-silver chloride electrodes coupled to the body surface through a conductive gel. The electrodes were fixed in place on the skin with the use of a double-sided adhesive film (Stomaseal). Placement of the electrodes was designed to maximize the QRS complex amplitude for signals ranging between 1/2 to approximately 3 millivolts.

Figure 1 is a circuit diagram of the EKG signal processor and radio frequency transmitter. Using currently available subminiature components, the complete circuit occupied an area of approximately 1-1/4" x 1-1/2", a depth of 3/8" and weighed 12 grams. The circuit was embedded in foam for mechanical support and attached to a body harness.

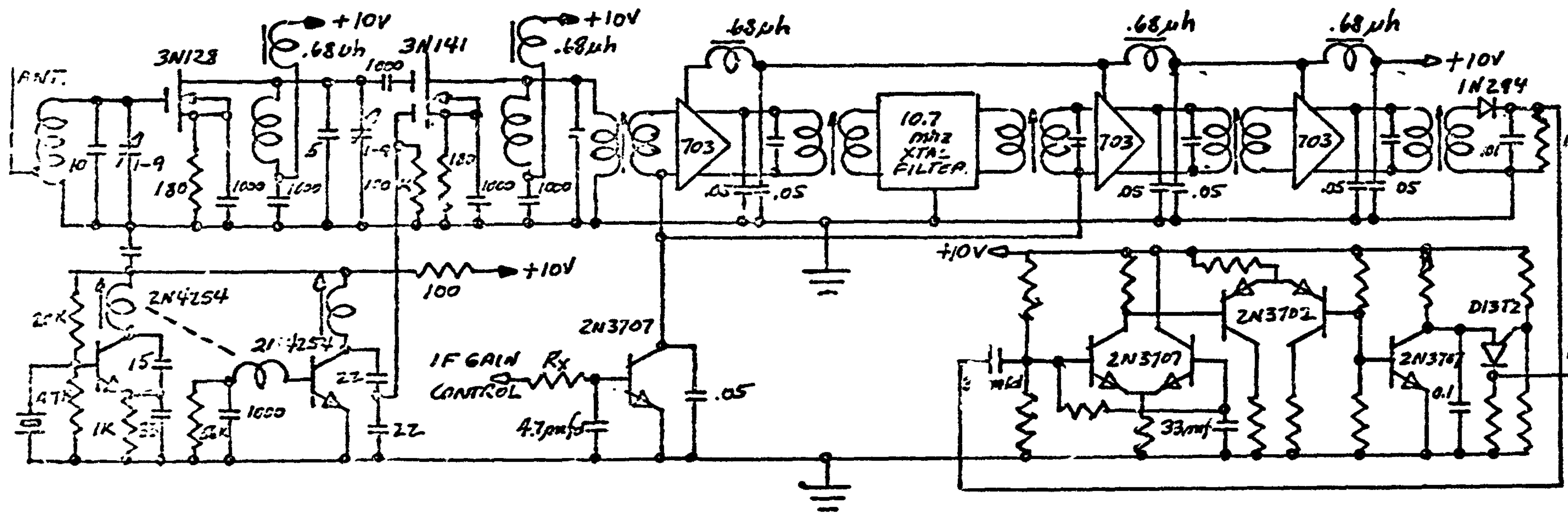


HEART RATE TRANSMITTER

fig. 1

Several antennas have been developed to provide line-of-sight ranges adequate for the study. The average power required from the battery sources depended on the heart rate and was nominally 1 milliamp at 3 volts under normal conditions. The transmitter circuit utilized a field effect transistor to provide high input impedance, a micropower operational amplifier in integrated form capable of providing off-on control of the remaining part of the circuit under normal EKG input. Two Schmitt trigger circuits were used to provide pulse forming and stretching. The effect was that the QRS complex initiated a switching pulse lasting approximately 15 milliseconds which controlled power to the radio frequency portion of the transmitter ciruit. The transmitter consisted of a crystal controlled oscillator and a doubler output stage. Signals from the transmitter then varied in accordance with heart rate and were capable of narrow band reception on the order of 2 kc bandwidth.

Figure 2 shows the circuit diagram of a portable battery operated solid-state receiver used in these experiments. The receiver has 0.1 microvolt sensitivity and bandwidth sufficient for the crystal stability and modulation requirements. The discriminator portion of the receiver circuit was designed to exclude or reject noise impulses and provide signals in accordance with data pulses of 13 to 15 ms in length. A pulse forming circuit provided power amplification for reshaped data pulses.



HEART RATE RECEIVER

fig. 2

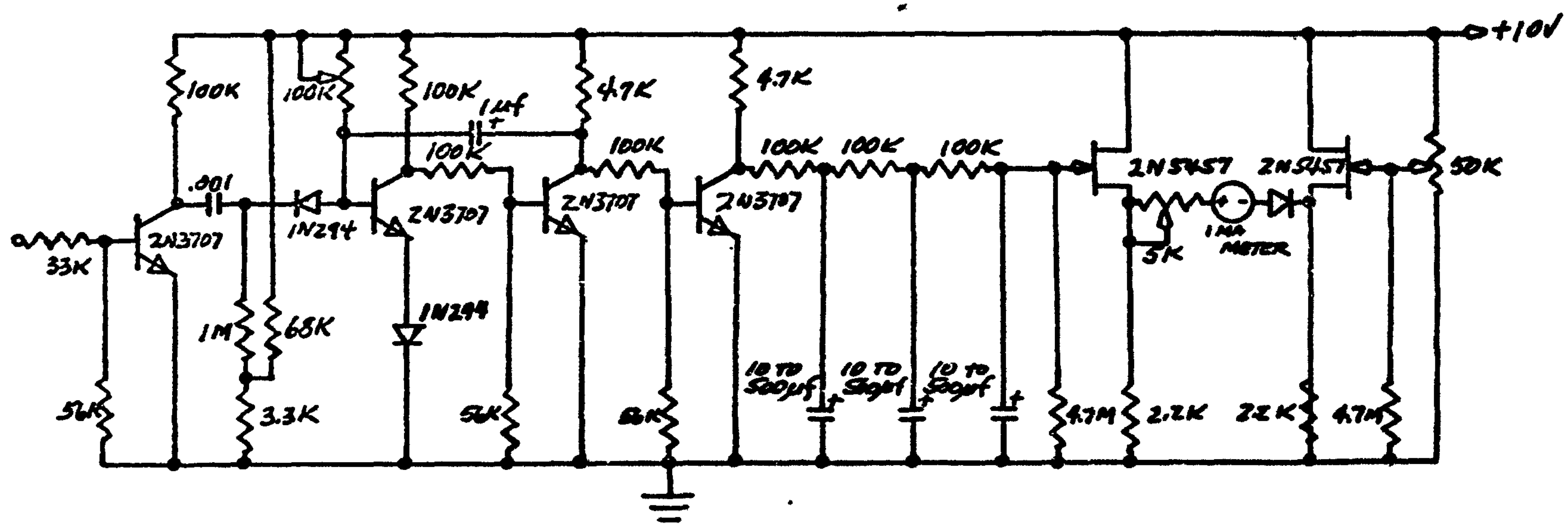
Figure 3 is the circuit diagram for the tachometer. It consists of an amplifier, a pulse reshaping circuit, a smoothing filter and an FET differential voltmeter. The output of the voltmeter was displayed either by meter movement or with a Rustrak recorder. Several time constants were available so that the tachometer circuit could emphasize slow heart rate change or rapid heart rate changes as desired.

The entire system was designed to be field portable so that the trainer could observe heart rate responses during field activity with dogs. While the circuit techniques were not extensively utilized with dogs, they were applied to the metabolic efficiency studies with free-flying sparrow hawks at the University of Utah at Logan, Utah, in collaboration with Dr. James A. Gessaman.*

2. Telemetry of Skin Temperature Changes:

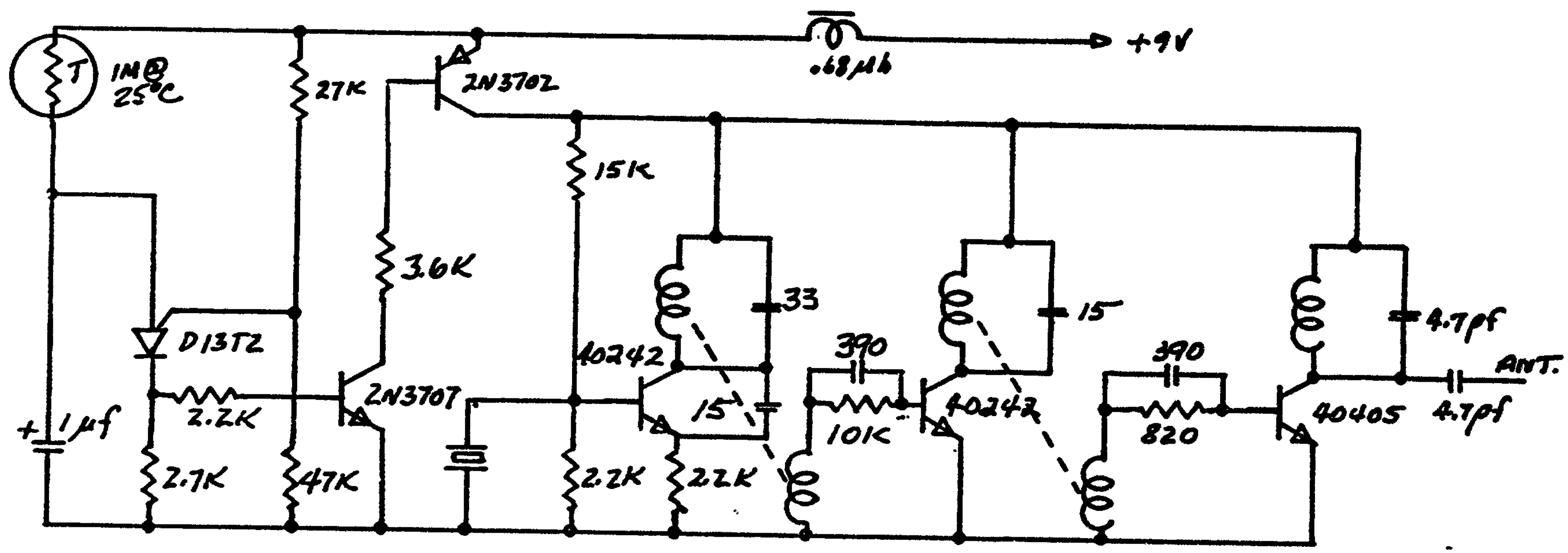
The basic circuit for telemetry of skin temperature fluctuations is shown in Figure 4. The pulse rate modulation for temperature is compatible with the heart rate readout and the same receiver-tachometer system is used. Thermistor bead sensors can be placed on the skin externally using either urethane or silicone foam to anchor the sensor to the hair on the dorsal surface of the neck. The foam tends to thermally isolate the thermistor from ambient temperature effects. Subdermal implant of the

* Baldwin, H. A., "Current Status of a Telemetry Applicable to Bioenergetics," Symposium on Ecological Energetics of Homeotherms: A View Compatible with Ecosystems Modeling; Colorado State University, Fort Collins, Utah (AIBS Annual Meeting, August 29 - September 3, 1971) To be published.



HEART RATE TACHOMETER

fig. 3



TEMPERATURE TRANSMITTER

fig.4

thermistor bead was used to verify the feasibility of external attachment.

Alerting responses are best demonstrated in records obtained with a trained bird dog. Figure 5 is a record of such activity with indications of various "points".

CONCLUSIONS

Technical feasibility of monitoring alerting responses due to heart rate changes and skin temperature variations was explored using externally mounted sensors and pulse rate telemetry. The experimental technique is capable of use under field conditions and has been applied to study of bioenergetics in the unrestrained sparrow hawk.

SKIN TEMPERATURE IN TRAINED BIRD DOG DURING HUNT

sensor location: dorsal superficial fascia of the neck.

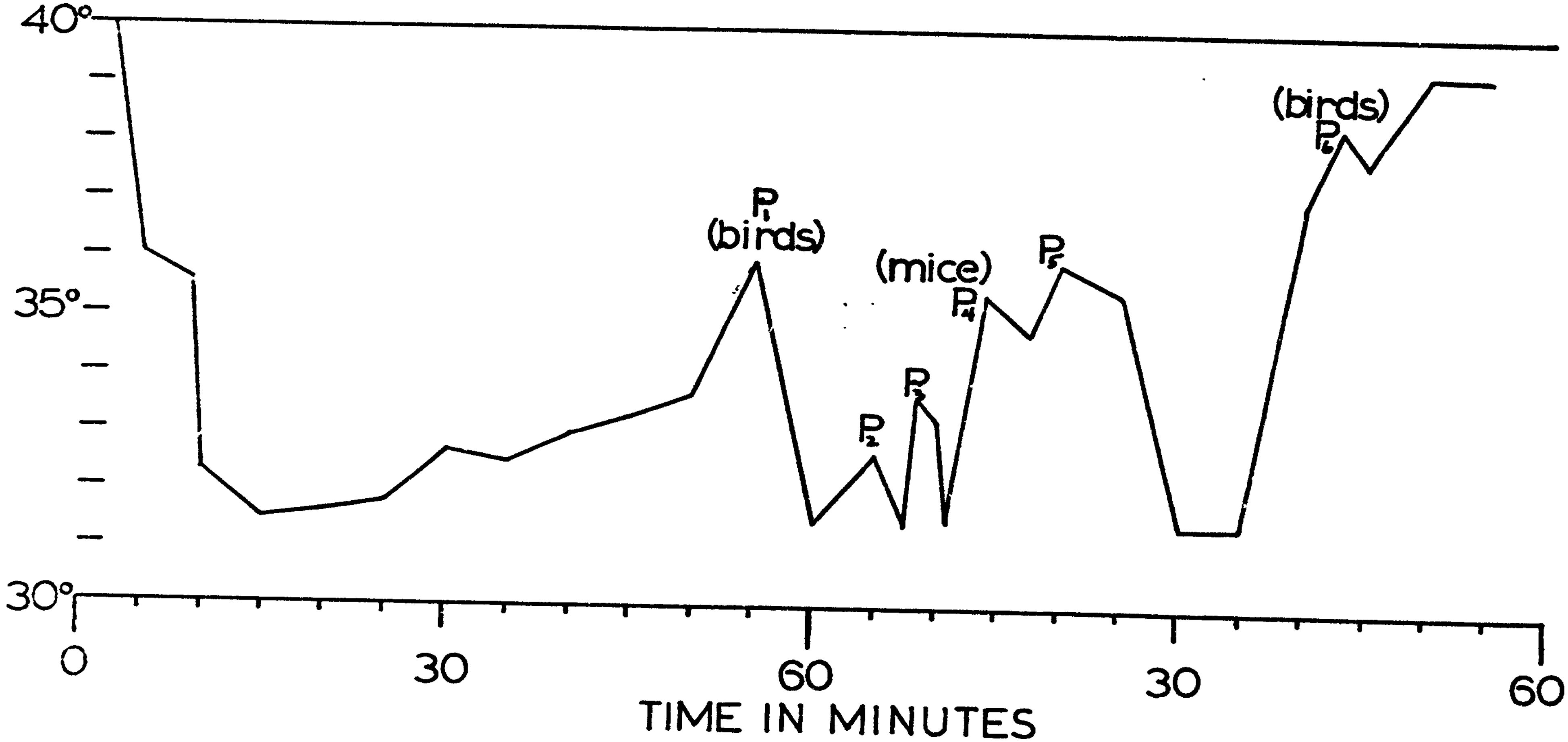


fig. 5